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Application Type: Invention

Title: Dissipative Automobile Exhaust Mufflers

Applicant: BYD LTD.

Inventors: Chuanfu Wang, Junqing Dong, Chunbo Li, Yi Liu

People's Republic of China
Commissioner of the State Intellectual
Property Office (signed) Wang Jingchuan
January 5, 2004

证　　明

本证明之附件是向本局提交的下列专利申请副本

申　　请　　日：　2003 04 24

申　　请　　号：　03 1 14334.2

申请类别：　发明

发明创造名称：　阻尼式汽车排气消声器

申　　请　　人：　比亚迪股份有限公司

发明人或设计人：王传福；刘毅；董俊卿；李春波

中华人民共和国
国家知识产权局局长　王景川

2004 年 1 月 5 日

权 利 要 求 书

1、阻尼式汽车排气消声器，包括金属外壳，此外壳的两端分别与进气管和出气管相连接，所述外壳内装有吸声材料，其特征在于：所述的吸声材料由发泡金属材料构成，发泡金属材料的发泡微孔的孔径为200-1200微米，孔隙率为80-98%。

2、根据权利要求1所述的阻尼式汽车排气消声器，其特征在于：所述的发泡金属材料沿着与气流方向垂直的方向分段设置，段与段之间留有空腔。

3、根据权利要求2所述的阻尼式汽车排气消声器，其特征在于：所述发泡金属材料的厚度为10-40毫米，所述空腔的厚度为10-50毫米。

4、根据权利要求2所述的阻尼式汽车排气消声器，其特征在于：各段的发泡金属材料可以分别具有不同的孔径或孔隙率。

5、根据权利要求1所述的阻尼式汽车排气消声器，其特征在于：所述的发泡金属材料以单层或多层方式以与气流方向平行的方向设置，各发泡金属材料层之间及其与外壳内壁之间留有空腔。

6、根据权利要求5所述的阻尼式汽车排气消声器，其特征在于：所述发泡金属材料的厚度为10-40毫米，所述空腔的厚度为10-50毫米。

7、根据权利要求1所述的阻尼式汽车排气消声器，其特征在于：所述的发泡金属材料为由镍、铁、钛组成的单质金属或合金。

8、根据权利要求1所述的阻尼式汽车排气消声器，其特征在于：所述的发泡金属材料为AB型合金，其中组份A为镍、铁、钛中的一种，其含量占55-95wt%，组份B为铬、铝、钴、钼、锌中的一种或几种，其含量占5-45 wt %。

9、根据权利要求1或7或8所述的阻尼式汽车排气消声器，其特征在于：所述发泡金属材料是采用电镀法制成的。

说　明　书

阻尼式汽车排气消声器

【技术领域】

本发明涉及一种汽车排气消声器，更具体的说涉及一种采用吸声材料的阻尼式汽车排气消声器。

【背景技术】

现有的汽车排气消声器系统通常以抗性消声器为主，因为它是全金属结构，结构简单，能耐高温、耐腐蚀、耐气流冲击，寿命长。但抗性消声器的消声频带较窄，在中、低频消声效果较好，高频较差。为了弥补其高频消声效果差的缺陷，往往需要采用多级组合即多级消声器或阻抗复合式消声器等对高频消声效果较好的结构，来完成汽车排气系统的消声。这样一方面增加了加工难度，另一方面也提高了消声成本。

现有的采用吸声材料的阻尼式排气消声器一般设置有气流通道，在气流通道中布置有吸声材料，吸声材料一般采用能耐高温、耐腐蚀的铝丝毡、石棉绳毡等，再用能牢固予以固定的护面结构加以固定。这种消声器耐冲刷、耐潮湿和耐尘的效果较差，使用寿命较短，同时消声效果也较差，因此目前还未能在汽车领域得到普遍使用。

【发明内容】

本发明所要解决的技术问题是，提供一种能耐高温、耐腐蚀、耐气流冲击，使用寿命长，消声性能好，同时结构简单、加工简便、成本较低的阻尼式汽车排气消声器。

本发明包括金属外壳，外壳的两端分别与进气管和出气管相连接，外壳内装有吸声材料。吸声材料由发泡金属材料构成，发泡金属材料的发泡微孔的孔径为 200-1200 微米，发泡金属材料的孔隙率（多孔材料的空气体积与材料总体积之比）为 80-98%。

所述的发泡金属材料可以沿着与气流方向垂直的方向分段设置，段与段之间留有空腔。也可以以单层或多层方式与气流方向平行的方向设置，各发泡金属材料层之间及其与外壳内壁之间留有空腔。所述

发泡金属材料的厚度为10-40毫米，所述空腔的厚度为10-50毫米。

采用发泡金属材料的消声器的工作原理是：当汽车尾气从进气管进入消声器壳体内后，进入发泡金属的孔隙中，在其中做轴向和径向的流动，声波被分散到多孔的发泡金属中，激发发泡金属中无数小孔内的空气介质振动，由于空气之间、空气与构成发泡金属微孔的经络之间的摩擦和粘滞作用，以及孔隙内的空气的涨缩作用，在空气与经络之间不断发生热交换，将声能转化为热能消耗掉，从而达到消声的目的。

由于本发明采用放置在消声器金属外壳内的发泡金属作为吸声材料，而发泡金属具有很高的孔隙率和较高的机械强度，同时还具有密度小、比表面积大、透流体性好、导热系数低、吸音减震力强等优点。把它用于汽车排气消声器的吸声材料，不仅吸声性能优良，而且具有加工简单，成本低廉，能耐高温、耐腐蚀、耐气流冲击，使用寿命长等优点。

由于发泡金属材料具有良好的机械强度和加工性能，消声器的外壳可以做成圆筒状，也可以方便地做成扁形或其他适应汽车底部空间的形状，而不会影响其内部结构的制作难度及最后器件的消声性能。

研究证明，发泡金属材料的孔径、孔隙率对材料的吸声性能和发动机的排气阻力有着很大的影响。经过多次试验证明，发泡金属材料的发泡微孔的孔径为200-1200微米、发泡金属材料的孔隙率为80-98%之间时能取得较好的吸声效果，同时当不设另外的气流通道，让发泡金属材料沿着与气流方向垂直的方向设置在金属外壳中时，能让高速排出的发动机气流顺利的通过，基本上不会影响发动机的性能。

本发明结构简单，加工简便，成本低廉，使用寿命长。在较宽的频率范围内都具有良好消声性能，平均消声效果比现在在汽车领域通用的抗性消声器提高了30%，比穿孔板消声器提高了约35-45%，检测结果如图5所示。与现有技术相比具有显著的经济、技术上的优势。

【附图说明】

下面结合附图和实施方式对本发明作进一步的详细说明：

图1是本发明阻尼式汽车排气消声器一种实施方式的结构示意

图；

图 2 是本发明阻尼式汽车排气消声器另一种实施方式的结构示意图；

图 3 是图 2 的 A 向视图；

图 4 是本发明所采用的一种发泡金属材料-发泡镍的微观结构图；

图 5 是本发明与其他几种通用消声器消声效果的比较图。

【具体实施方式】

本发明的一种实施方案如图 1 所示：包括金属外壳 2，外壳 2 的两端分别与进气管 2 和出气管 4 相连接，外壳 2 内装有由发泡金属材料构成的吸声材料 3。发泡金属材料的孔隙率可以在 80-98%之间，孔径可以在 200-1200 微米之间。吸声材料 3 分段（图中为两段，在实际使用中可以分为多段）沿着与气流方向垂直的方向设置在金属外壳 2 中，分段设置的吸声材料 3 之间留有空腔。发泡金属材料的厚度可以在 10-40 毫米之间，空腔的厚度可以在 10-50 毫米之间。

在本发明中，发泡金属材料的孔径对吸声性能有很大的影响，为了确定这项参数的最佳范围，做了七组试验，实验结果见表 1。表中孔径单位为微米。

试件代号	孔径	不同频率(Hz)下的吸声系数				
		100	500	1500	2500	4000
1	50	0.14	0.24	0.32	0.28	0.26
2	100	0.22	0.37	0.45	0.42	0.36
3	200	0.28	0.54	0.68	0.72	0.73
4	400	0.35	0.62	0.75	0.72	0.74
5	800	0.35	0.68	0.71	0.72	0.75
6	1200	0.32	0.61	0.72	0.72	0.65
7	1600	0.26	0.41	0.52	0.62	0.55

表 1

从表 1 中可以看到，发泡金属材料的孔径对于它的吸声性能有着很大的影响。其吸声系数随着孔径的增加呈现一个从低到高先上升，再从高到低下降的趋势，在 200-1200 微米之间时能够取得最佳吸声效果。同时还可以看出，发泡金属材料在高频部分的吸声效果要好于低频部分。

为了提高消声器的吸声性能，尤其是在低频部分的吸声性能，可以通过在吸声材料 3 之间留有的空腔，以及合理的增加材料的厚度等方式来达到这一要求。空腔客观上也可以起到增加材料厚度的作用，这相当于延长了毛细管的有效长度。由此可以减少材料的用量，降低了成本，同时还可以改善材料的吸声性能，尤其是低频部分的吸声性能。研究证明，当发泡金属材料的厚度在 10-40 毫米之间，空腔的厚度在 10-50 毫米之间时，就能够有效的提高吸声性能，特别是低频部分的吸声性能，使得本发明在一个宽广的频率范围内都能够获得良好的吸声效果。

发泡金属材料的孔隙率对于材料的吸声性能和气流阻力也有较大的影响。一般来说，较大的孔隙率有利于减少气流阻力，同时也能够提高材料的吸声性能，但是，如果把材料的孔隙率提高到 98%以上时，不仅在技术方面目前还比较困难,而且不经济，并且还会影响材料的机械强度，降低它的抗冲刷能力。因此把发泡金属材料的孔隙率限定为 80-98%是个最佳的范围。

设置在金属外壳内的多个发泡金属材料的孔隙率以及金属材料之间的空腔厚度可以相同也可以不同。通过选择设置在金属外壳内的多个发泡金属材料的不同的孔隙率与它们之间的不同的空腔厚度，可以进一步提高在较宽频率范围内的消声效果。

由于本发明所采用的发泡金属材料具有较高的孔隙率 (80-98%)和较大的孔径(200-1200 微米)，同时又具有较高的机械强度，能让发动机排出的气流顺利的通过。因此，本发明可以不设另外的气流通道，可以让发泡金属材料沿着与气流方向垂直的方向设置在金属外壳 2 中。采用常规的方式如焊接、加用护面结构等方法进行固定。这样可以取得最佳的吸声效果。

但发泡金属材料也可以采用如图 2 和图 3 所示的，沿着与气流方向平行的方向设置等方式，在发泡金属材料制成的吸声材料 3 的中间以及吸声材料 3 与金属外壳 2 之间也可以形成气流通道。这样的话，对发动机的排气阻力更小，但吸声效果稍有下降。如此设置的发泡金属材料 3 的数量可以为一层或者多层。各发泡金属材料层之间及其与外壳内壁之间留有空腔。发泡金属材料的最佳厚度在 10-40 毫米之间，空腔的最佳厚度在 10-50 毫米之间。

上述的发泡金属材料可以包括：镍、铁、钛组成的单质金属或者由上述金属构成的合金。也可以为 AB 型合金，其中组份 A 为镍、铁、钛中的一种，其含量占 55-95%（重量百分比），组份 B 为铬、铝、钴、钼、锌中的一种或几种，其含量占 5-45 %（重量百分比）。

采用发泡合金材料可以进一步提高材料的机械强度和抗氧化、抗热腐蚀性能，提高抗冲刷能力，延长消声器的使用寿命。

图 4 展示了本发明所采用的一种发泡金属材料-发泡镍的微观结构。在图中可以清楚的看到，发泡镍具有三维网状结构，骨架彼此相连，所有孔隙都是相通的，因此具有很高的孔隙率和较高的机械强度。发泡镍还具有密度小、比表面积大、透流体性好、导热系数低、吸音减震力强等优点。因此采用发泡镍作为吸声材料能取得极佳的消声效果并减少对发动机排气的阻力。

发泡金属材料最好采用电镀法制成。尤其是对制造大孔率发泡金属，最为简单、方便。通过电镀法制造发泡金属不仅简单、方便、成本低，同时采用这种方法制成的发泡金属吸声性能优良，还具有与其它制造方法相比更好的机械强度、导热性和化学稳定性，能够延长发泡金属材料的使用寿命。但发泡金属材料也可以采用其他通用的方法制备。

【实施例一】

将用作吸声材料的发泡金属材料分两段沿着与气流方向垂直的方向设置在消声器的金属外壳中。采用焊接的方式进行固定。分段设置的吸声材料之间以及吸声材料与消声器外壳之间留有空腔。发泡金属材料的孔隙率可以在 80-98%之间，最好能达到 95-98%; 孔径为 200 微米；厚度可以在 10-40 毫米之间；空腔的厚度可以在 10-50 毫米之

间。 发泡金属材料采用发泡镍，发泡镍采用电镀工艺制备，质量应该达到孔隙分布均匀、无封孔、无穿孔、有较高的机械强度和一定的柔韧性。

对实施例一用于普通轿车，使用机动车辆定置噪声测量方法（GB/T 14365-93）和汽车加速行驶车外噪声限值及测量方法（GB 1495-2002），在不增加油耗的前提下，噪声值均低于国家规定的噪声限值。

【实施例二】

发泡金属材料采用发泡镍，孔径为 400 微米，其他与实施例一相同。

【实施例三】

发泡金属材料采用发泡镍，孔径为 800 微米，其他与实施例一相同。

【实施例四】

发泡金属材料采用发泡镍，孔径为 1200 微米，其他与实施例一相同。

【实施例五】

发泡金属材料采用发泡镍，孔径为 200 微米，发泡镍在圆筒形外壳 2 内沿着与气流方向平行的方向呈与外壳相应的形状，也呈圆筒形设置。呈圆筒形设置的发泡镍内部及发泡镍与消声器外壳内壁之间留有空腔。其他与实施例一相同。

【实施例六】

发泡金属材料采用发泡镍-铬合金，其中金属镍含量为 55wt%、铬含量为 45wt%，孔径为 200 微米，其他与实施例一相同。

由于镍基合金在高温中具有很高的强度和良好的抗氧化、抗热腐蚀性能，因此使用寿命更长。

【实施例七】

发泡金属材料采用发泡镍-铬合金，其中金属镍含量为 75wt%、

铬含量为 25wt%，孔径为 200 微米，其他与实施例一相同。

【实施例八】

发泡金属材料采用发泡镍-铬合金，其中金属镍含量为 95wt%、铬含量为 5wt%，孔径为 200 微米，其他与实施例一相同。

对上述实施例用于普通轿车按照实施例一所述的方法进行检测，噪声值均低于国家规定的噪声限值。

采用其它发泡金属材料如铁、钛等及上述金属的合金和不同结构和孔径做上述试验，试验结果，噪声值均低于国家规定的噪声限值。

上述实施例只是体现本发明基本思路的优选方案，本技术领域的普通技术人员对其中的某些部分所可能做出的一些变动均体现了本发明的原理，属于本发明的保护范围之内。

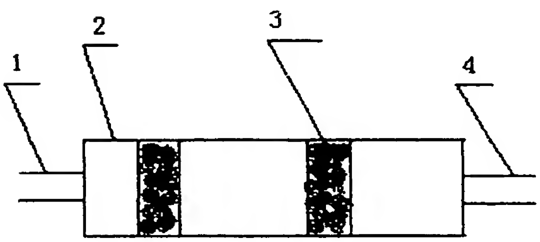


图 1

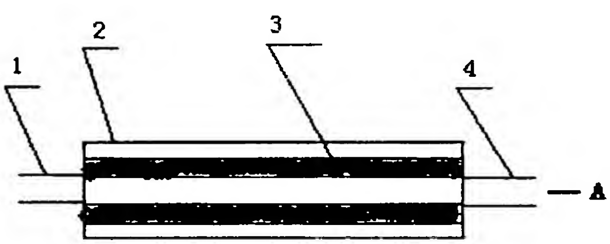
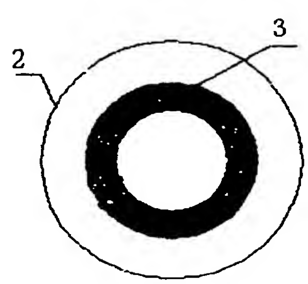


图 2



A向

图 3

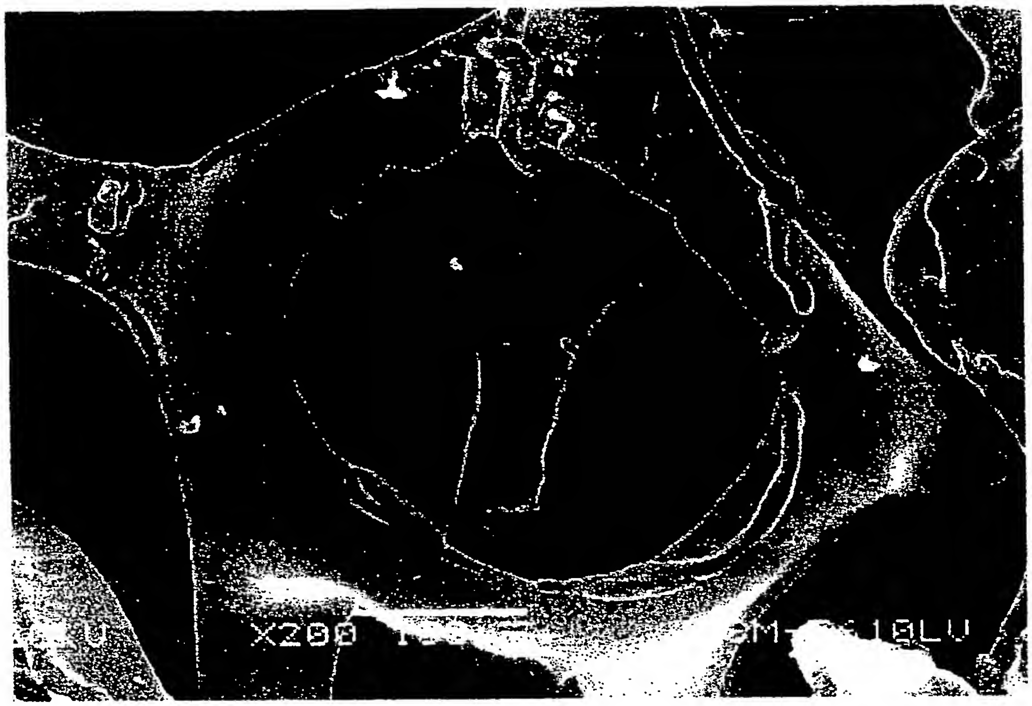


图 4

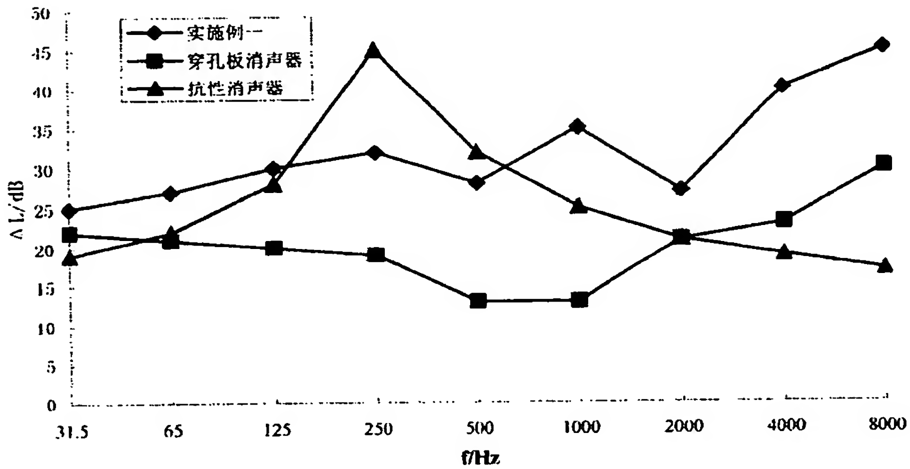

50
45
40
35
30
25
20
15
10
5
0
ΔL/dB
实施例一
穿孔板消声器
抗性消声器
31.5
65
125
250
500
1000
2000
4000
8000
f/Hz

图 5

ENGLISH TRANSLATION DOCUMENT

The following attached document is the English Translation Document for the below referenced Chinese patent application.

Application Date: 2003 4 24

Application Number: 03 1 14334.2

Application Type: Invention

Title: Dissipative Automobile Exhaust Mufflers

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Attorney Docket: BYD-US2003-003

Translation Certification

I hereby certify that the following translation of the respective certified copy is correct.

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Abstract

This invention relates to an automobile exhaust muffler, comprising of a metal outer shell that holds a sound absorption medium. The two ends of the outer shell are connected with the intake and outtake pipes. The sound absorbing material is made of porous metal where the pores inside the porous metal have diameters of between 200 to 1200μm. The pore density is 80-98%. This type of exhaust muffler is of simple construction and easy to fabricate. Its cost of production is low. It can also withstand high heat, corrosion, and impact from air flow. It has a long life span as well as good sound muffling characteristics.

Claims

1. A type of dissipative style automobile exhaust muffler, including a metal outer shell. Also, the two ends of the metal shell are connected separately to the intake and outtake pipes. Said outer shell holds a sound absorbing material. Its characteristics are: said sound absorbing material is made from porous metal where the pores in the porous metal have diameters of between 200μm and 1200μm and the pore density of the porous metal is 80-98%.

2. The dissipative style automobile exhaust muffler of claim 1, its characteristic is: said porous metal can be placed in sections perpendicular to the direction of the airflow, with gaps between the sections.

3. The dissipative style automobile exhaust muffler of claim 2, its characteristic is: the thickness of said porous metal material is between 10mm and 40mm and the thickness of said gaps is between 10mm and 50mm.

4. The dissipative style automobile exhaust muffler of claim 2, its characteristic is: each section of porous metal material can have different pore diameter or pore density.

5. The dissipative style automobile exhaust muffler of claim 1, its characteristic is: said porous metal can also be placed either in single or multiple layers in the direction parallel to the direction of the air flow, leaving gaps between the layers of porous metal, and between the inside of the outer shell and the layers of porous material.

6. The dissipative style automobile exhaust muffler of claim 5, its characteristic is: the thickness of said porous metal material is between 10mm and 40mm and the thickness of said gaps is between 10mm and 50mm.

7. The dissipative style automobile exhaust muffler of claim 1, its characteristic is: said porous metal material is a metal element or metal alloy made from the following: nickel, iron, and titanium.

8. The dissipative style automobile exhaust muffler of claim 1, its characteristic is: said porous metal material is made with a combination of metals or alloys from two groups (A & B). Group A consists of 55 to 95wt% of the porous metal and contains one of the following: nickel, iron or titanium. Component B consists of 5 to 45wt% of the porous metal and contains one or more of the following: chromium, aluminum, cobalt, molybdenum, and zinc.

9. The dissipative style automobile exhaust muffler of claim 1, claim 7 or claim 8, its characteristic is: said porous metal material is fabricated with electroplating.

Specification

Dissipative Automobile Exhaust Mufflers

Field of Invention

This invention relates to a type of automobile exhaust muffler. More particularly, it relates to a type of dissipative style automobile muffler that uses sound absorbing material.

Background of Invention

Existing automobile exhaust muffler systems customarily mainly use reactive type mufflers because these systems are made from metal, with simple structures that can withstand high temperature, corrosion, impact from air flow, and have a long lifespan. However, the spectrum for sound absorption of reactive type mufflers is narrower with better results in the low frequencies and worse in the high frequencies. In order to compensate for the weakness in high frequency sound absorption and achieve sound absorption for the automobile exhaust system, structures such as multi-stage combinations, i.e., multi-stage muffler devices or dissipative and reactive combination style mufflers are often needed for better results in high frequency sound absorption. However, these methods increase the complexity of the technology and increase the cost for sound absorption.

Existing dissipative type exhaust mufflers using sound absorption material customarily have air circulation passages containing sound absorption materials. These sound absorption materials are made of materials such as aluminate felt and asbestos felt that and can usually resist high heat and corrosion. They are firmly secured to a securable surface

protecting structure. These mufflers' ability to resist impact, humidity, and dust are relatively low resulting in comparatively short useable life spans. At the same time, their sound absorption capability is also relatively weak. Therefore, at present, they are not widely used in the automobile industry.

Description of Invention

The technological problem that this invention solves is to provide a dissipative style automobile muffler that is resistant to high temperature, corrosion, and impact from air flow with good sound absorption properties, of simple construction and technology, and is of low cost.

This invention includes a metal outer shell where the two ends of the metal shell are connected to the intake and outtake pipes. The outer shell holds a sound absorbing material. The sound absorbing material is made from porous metal where the pores inside the porous metal have diameters between 200μm and 1200μm. The pore density of the porous material, i.e., the percentage of volume of pores to the volume of the total porous metal, is between 80% and 98%.

Said porous metal can be placed in sections perpendicular to the direction of the airflow, with gaps between the sections. In the alternative, said porous metal can also be placed either in single or multiple layers in the direction parallel to the direction of the air flow, leaving gaps between the layers of porous metal, and between the inside of the outer shell and the layers of porous material. The thickness of said porous material is between 10mm and 40mm and the thickness of the gaps is between 10mm to 50mm

The reason for using the porous metal material for the sound absorption function is: after the exhaust enters the inside of the body of the shell of the muffler from the intake pipe,

it enters the pores of the porous metal and moves along and perpendicular to the direction of flow inside the pores. The sound waves are distributed to the many pores inside the porous metal, stimulating the air medium inside the many small pores to vibrate. Within the air in the pores, due to the friction and adhesive action between the air and the channels that form the pores of the porous metal and the expansion and contraction action of the air in the pores, there is a continuous heat exchange between the air and the channels resulting in the transformation of sound energy into heat that then dissipates. From this, the goal for sound absorption is achieved.

This invention places porous metal as the sound absorbing material inside the metal outer shell of the muffler where the porous metal has advantages such as a high pore density, higher mechanical strength, low density, large specific surface area with good flow through characteristics, low thermal conductivity, and strong absorption of sound vibrations. Using this material as the sound absorption material for the automobile exhaust muffler not only produces excellent sound absorption properties but also possesses other advantages as well. Its technology is simple. Its cost is low and it can withstand high temperature, corrosion, and impact from air flow. It has a long useable lifespan.

Because of the strength of the porous metal material and its ease of manufacturability, the outer shell for the muffler can be cylindrical shaped. It can also be conveniently made into flat shaped or other shapes that can adapt to the space at the automobile's underside without affecting the difficulty in the fabrication of its internal structure or the sound absorption property of the final device.

Research proves that the pore diameter and the pore density have a large effect on the sound absorption property of the material and the resistance of the exhaust from the engine.

Multiple experiments prove that porous metal with pore diameter between 200μm and 1200μm and pore density of between 80% and 98% can produce better sound absorption results. Even when the porous metal is placed inside the metal outer shell perpendicular to the direction of the air flow such that there is no other pathway for the air to flow at the same time, the device allows the high speed exhaust from the engine to flow smoothly through and fundamentally does not affect the properties of the engine.

This invention has a simple structure, is easy to manufacture, of low cost, and has long useable life span with good sound absorption properties in a wider frequency spectrum. When compared with existing reactive type mufflers commonly used in the automobile industry, the average sound absorption effect of this invention is 30% better. When compared with mufflers with perforated panels, its sound absorption effect is better by 35% to 45%. The test results in Figure 2 indicate that, when compared with existing technology, this invention has distinctive economical and technological advantages.

Description of Attached Drawings

The following attached figures and embodiments describe this invention in further detail.

Figure 1 is the diagram of the structure of an embodiment of the dissipative style automobile exhaust muffler of this invention.

Figure 2 is the diagram of the structure of another embodiment of the dissipative style automobile exhaust muffler of this invention.

Figure 3 is the diagram of the structure of the embodiment of this invention as shown in Figure 2 when viewed from the direction of "A" as shown in Figure 2.

Figure 4 is the micrograph of the structure of porous nickel, a porous metal material used in an embodiment of this invention.

Figure 5 is a chart comparing the effect of sound absorption results between the mufflers of this invention and several other types of commonly used mufflers.

Particular Implementation Methods

Figure 1 shows an embodiment of this invention including the outer metal shell (2). The two ends of the outer shell are separately connected with the intake pipe (2) and the outtake pipe (4). The outer shell (2) holds the sound absorbing material made of porous metal (3). The relative density of the porous metal can be between 80-98%. The pore diameter can be between 200-1200μm. The sound absorbing material (3) is in sections and placed perpendicular to the direction of the airflow inside the outer shell (2). (Figure 2 shows two sections. In practice, multiple sections can be used.) The sections of sound absorbing material of thickness can be between 10mm and 40 mm and the thickness of gaps can be between 10mm and 50mm.

In this invention, the size of the pore diameter in the porous metal material greatly affects its ability to absorb sound. Seven groups of experiments were conducted in order to determine the best range for this parameter. The results are shown in Table 1 with the pore diameter in micrometers.

Table 1

Test Sample No.	Pore Diameter (μm)	Acoustic Absorption Coefficient at Different Frequencies (Hz)				
		100	500	1500	2500	4000
1	50	0.14	0.24	0.32	0.28	0.26

2	100	0.22	0.37	0.45	0.42	0.36
3	200	0.28	0.54	0.68	0.72	0.73
4	400	0.35	0.62	0.75	0.72	0.74
5	800	0.35	0.68	0.71	0.72	0.75
6	1200	0.32	0.61	0.72	0.72	0.65
7	1600	0.26	0.41	0.52	0.62	0.55

Table 1 shows that the pore diameter of the porous material greatly affects its sound absorption property. As the pore diameter increases, the acoustic absorption coefficient first increases and then decreases. Best sound absorption is obtained when the pore diameter is between 200 to 1200 micrometers. Also, sound absorption is better at higher than lower frequencies.

In order to increase the sound absorption, especially at lower frequencies, methods such as leaving gaps between the sections of sound absorbing material (3) and increasing the thickness of the material can be used. Theoretically, gaps can also have the effect of increasing the material's thickness. This is equivalent to increasing the effective length of the capillaries. This will decrease the use of materials, lower cost, and improve the material's sound absorption properties, especially at the lower frequencies. Research proves that, especially at lower frequencies, sound absorption increases when the thickness of the porous material is between 10mm and 40mm., and the size of the gap is between 10mm and 50mm; thus allowing this invention to obtain good sound absorption in a wide spectrum of frequencies.

The pore density of the porous material has a bigger effect on the sound absorption and air resistance. Generally speaking, large pore density has the advantage of decreasing air

resistance and increasing the sound absorption. However, if the pore density is increased to above 98%, the fabrication technology becomes more difficult and non-economical. Also, at that density, the structural strength is affected, lowering its ability to resist mechanical impact. Therefore, the best range for the pore density should be between 80% and 98%.

The pore density of the different sections of sound absorption material placed inside the outer shell can vary. In addition, the size of the gap between the sections can also vary. The sound absorption can be further improved to a wider spectrum of frequencies by adjusting the pore density of the different sections of porous metal material inside the outer shell and the size of the different gaps.

Since this invention uses porous metal with a higher pore density (80 to 98%), and a larger pore diameter (200-1200 micrometers), with a higher mechanical strength, therefore, exhaust from the engine can flow smoothly through without additional air channels. This allows the porous metal to be placed in the outer metal shell (2) perpendicular to the direction of the airflow using customary methods such as welding and securing with other additional methods to protect the surface structure. In this manner, the best results for sound absorption can be obtained.

The porous material can also be positioned as shown in Figure 2 or Figure 3, parallel to the direction of the airflow with gaps between the sections of sound absorption material (3), and the outer shell (2) and the sound absorption material (3). This configuration further lowers the pressure from the engine exhaust but slightly lowers the sound absorption results as well. One or more layers of sound absorption materials (3), with gaps between the layers and between the material and the walls of the outer shell can also be used in this

configuration. The best specifications for the thickness of the porous metal and size of the gaps are the same as described above.

The above-described porous metal can be made from a single element of nickel, iron, titanium or an alloy of above-stated metals. It can also be made with a combination of metals or alloys from two groups (A & B.). Group A consists of 55 to 95 wt.% of the porous metal and contains one of the following: nickel, iron or titanium. Component B consists of 5 to 45 wt.% of the porous metal and contains one or more of the following: chromium, aluminum, cobalt, molybdenum, and zinc.

The porous metal can further improve the mechanical strength, resistance to oxidation, heat corrosion, and impact of the material and increase the useable life span of the muffler.

Figure 4 shows the microscopic structure of a type of porous nickel. The picture clearly shows that the porous nickel has a three dimensional net structure, with its skeletal structure connected and all cavities connecting thus showing that its has a high pore density and good structural strength. Porous nickel also has the following advantages: low density, high specific surface area, good flow through properties, and low coefficient of heat conduction. Therefore excellent sound absorption results with lowered engine exhaust pressure can be obtained using porous nickel as the sound absorption material

Although other methods can be used to fabricate porous metal, electroplating is the best. For fabrication of porous metal with high pore density, electroplating is simple, convenient, and cheap. When compared with other methods of fabrication, porous metal fabricated by electroplating not only has excellent sound absorption properties, it has better structural

strength, heat conductance and chemical stability, resulting in a longer useable lifespan of the porous metal.

Embodiment 1

The sound absorbing material fabricated from porous nickel by electroplating is secured by welding in two sections to the inside the outer metal shell of the muffler perpendicular to the air flow. Gaps are left between the porous metal and the outer shell and between the different sections of the porous metal. The pore density can be between 80 and 98%, best when it can be between 95 and 98%. The pore diameter is 200μm. The thickness of the porous metal is between 10 and 40 mm; the thickness of the gap is between 10 and 50 mm. The porous nickel, fabricated using electroplating, should have evenly spaced pores, with no orifices or pores with holes, thus having higher structural strength and pre-determined flexibility.

Using the Test Method for Noise Limitation for Mechanical Automobile (GB/T 14365-93) and Limit and Testing Method for External Noise for Acceleration of Automobile (GB 1495-2002), under the condition of no increase in oil consumption, in commonly used sedans, the noise levels are all lower than the national standards.

Embodiment 2

Porous nickel with pore diameter of 400μm is the porous metal material. Everything else is the same as Embodiment 1.

Embodiment 3

Porous nickel with pore diameter of 800μm is the porous metal material. Everything else is the same as Embodiment 1.

Embodiment 4

Porous nickel with pore diameter of 1200μm is the porous metal material. Everything else is the same as Embodiment 1.

Embodiment 5

Porous nickel with pore diameter of 200μm is the porous metal material. The porous nickel has a cylindrical shape corresponding to the shape of the outer shall and is placed inside the cylindrical shell, parallel to the cylindrical outer shell and in the direction parallel to the air flow. There is an gap between the outer shell of the muffler and the cylindrical shaped porous nickel. Everything else is the same as Embodiment 1.

Embodiment 6

Porous nickel chromium alloy containing 55 wt% of nickel and 45wt% of chromium and with pore diameter of 200μm is the porous metal material. Everything else is the same as Embodiment 1.

Embodiment 7

Porous nickel chromium alloy containing 75 wt% of nickel and 25wt% of chromium and with pore diameter of 200μm is the porous metal material. Everything else is the same as Embodiment 1.

Embodiment 8

Porous nickel chromium alloy containing 95 wt% of nickel and 5wt% of chromium and with pore diameter of 200μm is the porous metal material. Everything else is the same as Embodiment 1.

The above-described embodiments were used with commonly used sedans and tested with the method described in Embodiment 1; all noise levels were below national standards.

When other porous metals such as iron, titanium or above-described metals alloys with different structure and pore diameters are used and tested, all test results show that the noise level is lower than the national standards.

Above-described embodiments are some preferred implementations that realize the fundamental ideas of this invention. To implement the theory of this invention, persons having ordinary skill in the field of this invention can make some changes to certain parts. However, those changes still remain within the realm of protection of this patent.

Figure 1

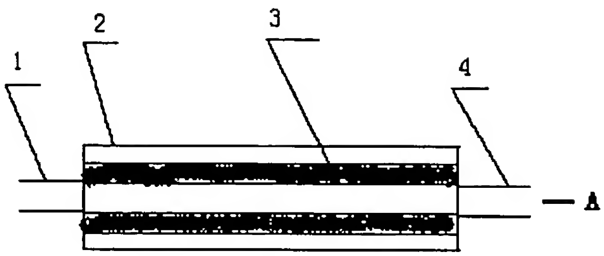


Figure 2

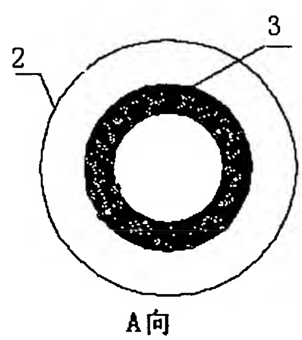
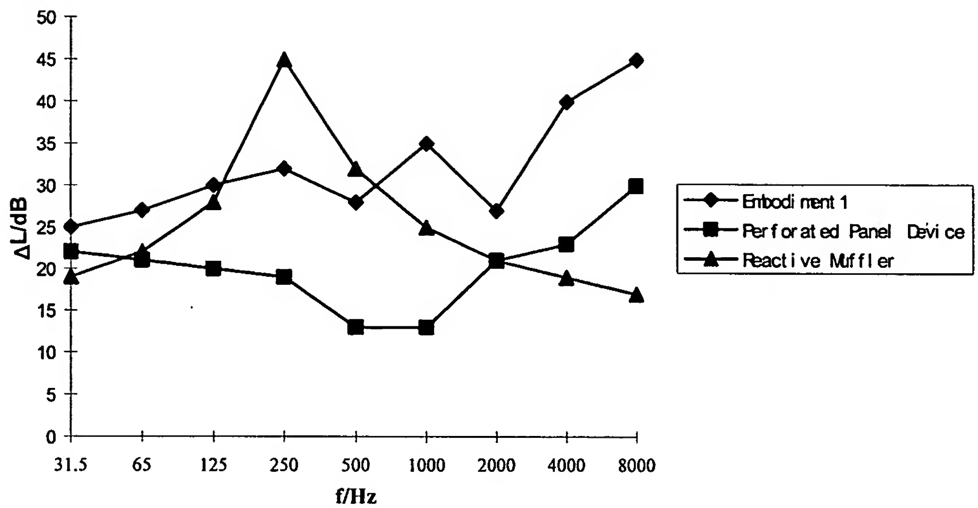


Figure 3

Figure 4



50
45
40
35
30
25
20
15
10
5
0
ΔL/dB
31.5
65
125
250
500
1000
2000
4000
8000
f/Hz
Embodiment 1
Perforated Panel Device
Reactive Muffler

Figure 5